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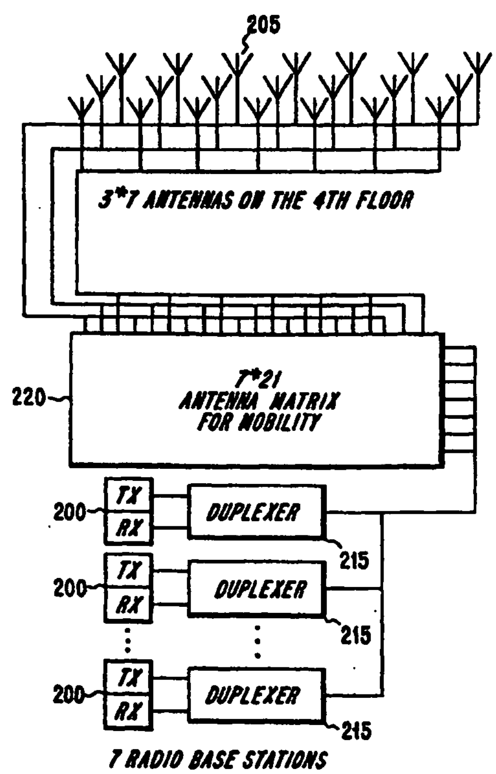
(54) Title: RADIOCOMMUNICATION TEST SYSTEM WITH INTERNET PROTOCOL ADDRESSED CLUSTERS

(57) Abstract

A test system is described for testing fixed and mobile portions of a wireless telecommunication systems. The mobile portion can be represented by a cluster of mobile units in a IP-addressable housing. The housing can be connected to the computer workstation using an IP-compatible network, e.g. a LAN or a wireless IP network. In an exemplary embodiment of the invention, ten mobiles are removably disposed in cradles embedded in the IP-addressable housing. Each mobile is connected to a separate port of an IP server within the housing. A power supply may also be included.



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RADIOCOMMUNICATION TEST SYSTEM WITH INTERNET PROTOCOL ADDRESSED CLUSTERS

BACKGROUND

The present invention relates generally to wireless telecommunication systems. More specifically, the invention relates to a system for testing an air interface of wireless telecommunication systems.

In a cellular telecommunication system, a mobile switching center (MSC) is linked to a network of base stations by a series of digital transmission links. The base stations are geographically distributed to form an area of coverage for the system. Each base station is designated to cover a specified area, known as a cell, in which a two way radio communication can take place between a mobile station and the base station in the associated cell. The mobile station operating within a cell communicates with the base station over the air interface on a specified radio channel. For simplicity, the term mobile station will henceforth be referred to simply as the mobile.

Manufacturers of wireless telecommunication equipment have long recognized the importance of testing the equipment prior to installation in the field. Many of the tests performed on the base station equipment and the mobile switching center (MSC) are typically well developed and do a good job of simulating real-life conditions. Other areas, such as those involving the air interface, have generally not been tested as rigorously, partly due to the inherent environmental randomness associated with the radio path thus leading to a lack of repeatability in testing procedures. For example, the actual environment a service provider operates in can contain a number of factors that are difficult to recreate in a test environment such as changing weather conditions, interfering signals, log normal and multi-path fading from obstacles and/or terrain, etc. The precise conditions are often difficult to recreate in a laboratory back at the manufacturing site.

A further complicating factor is that there is a limit to the amount and types of tests that can be performed at the installation site without significantly affecting current service. Since the environmental conditions at an operating site cannot be guaranteed to

remain consistent, it may be difficult to compare results from repeated tests with much confidence. Thus, the system reliability and robustness of the controlling software become difficult to verify from repeated testing where conditions need to be held constant.

In prior testing methods, there have been attempts made to simulate the air interface in testing procedures in a laboratory environment. One example known in the art is to use a coaxial cable to connect the mobile to the base station to form a coaxial network air interface. This type of system has a number of disadvantages, notably that the isolated coaxial cables do not provide a suitable life-like radio path that is susceptible to any number of problematic elements as in an actual operating environment. A more detailed discussion of a coaxial network for simulating the air interface is described in U.S. Patent No. 5,465,393 granted to Frostrom et al. entitled: "Simulated Air Interface System for Simulating Radio Communication", issued on November 7, 1995 to the present assignee, the disclosure of which is incorporated by reference herein in its entirety.

Fig. 1 illustrates a typical prior art coaxial network testing system for use in simulating the air interface for test operations. A plurality of mobiles, referred collectively by the reference numeral 100, are each connected to a base station 110 via coaxial cables 120. The connection is made by connecting one end of coaxial cable 120 to the antenna port of each of the mobiles and connecting the other end to base station 110. The cables provide individual shielded radio paths to and from each of the mobiles to the base station thus allowing a large number of mobiles to be conveniently tested from one location. In addition, precise control of the signal strengths to and from the mobile can be achieved thereby providing suitable conditions for repeat testing. A computer 130 is connected via link 140 to each of the mobiles in order to automate the testing procedure and monitor and record the results.

A disadvantage of using such a coaxial test network is that the same radio path is used for both the transmission and reception of signals thereby unrealistically isolating the mobile from signals from other mobiles, e.g., removing the effects of co-channel interference and adjacent channel interference. This is not suitable for testing problems

arising from the interaction of signals from other mobiles such as mass traffic testing. Mass traffic testing includes testing the system during mass registrations and mass call setups by a large number of mobiles which better simulates real-life situations. This has become an area of growing importance since sustained high traffic conditions may lead to access collisions arising from a large number of mobiles attempting to simultaneously access a limited bandwidth channel. Thus, a coaxial based network is unsuitable for this type of testing.

This problem is addressed in copending U.S. Patent Application Serial No. ____________________, entitled "Air Interface Based Wireless Telecommunication Test System", filed on November 19, 1998 to Per Green. Therein, an indoor antenna test system for use in testing wireless telecommunication systems is described. The test system includes a antenna array having a plurality of individual antennas that are deployed in a predetermined and fixed pattern within a confined testing area such as a building or a laboratory. Further, a plurality of base stations are connected to the antenna via an antenna matrix. When the antenna matrix makes a connection between a base station and an antenna, a cell is activated accordingly. The antenna matrix can be controlled by a computer workstation to automatically activate cells in a predetermined sequence according to a specified testing procedure.

If tests are to be performed using the real air interface, a problem associated with conventional radiocommunication test systems is that they typically require that a number of people act as testers who move around the test site, each manually operating a mobile phone. Apart from employing people, this creates difficulties in simulating certain types of traffic conditions, e.g,. a large number of simultaneous system accesses. Moreover, repeatability of testing is difficult given the manual component of the test environment. The manual work involved as described above is also a limiting factor to the duration of the tests.

These problems have been partially addressed in the system described in WO 98/31174, entitled "Method and Arrangement for the Controlled Generation of a Traffic Load in Mobile Radio Systems", the disclosure of which is expressly incorporated herein by reference. Therein, mobile stations are controlled and monitored by a control

computer, which mobile stations communicate with a fixed part of the radiocommunication system via radio channels. However, the test system architecture described in WO 98/31174 leaves much to be desired.

For example, in the two embodiments illustrated in this document, the computer is connected to each mobile station individually over a CAN bus. The CAN bus employs a unified test bus protocol (UTBP) for transferring information between the computer and the mobile stations, which protocol is described as "tailor-made" for this particular application. In one embodiment, a controller module (CM) is provided for each mobile station, which CM interfaces the monitoring computer with mobile station, e.g., to translate the UTBP signals into manufacturer-specific commands that each mobile unit will recognize.

These architectural features of the system described in WO 98/31174 render the system complicated and expensive to manufacture, e.g., by using dedicated controller modules for each mobile station. Moreover, the dedicated wiring between each mobile station and the monitoring computer, as well as the special purpose UTBP protocol, make it difficult (or impossible) to employ existing computer network infrastructures to implement the test system. Additionally, such a test system is costly and time consuming to install/modify if a large number of mobiles are connected over large distances.

In view of the foregoing, it is desirable to create a radiocommunication test system architecture that is flexible, economical and easily adaptable to changing test configurations.

SUMMARY

According to exemplary embodiments of the present invention, these and other drawbacks and limitations of conventional test systems are overcome by providing Internet Protocol (IP)-addressable test clusters of mobile units. Each cluster contains a plurality of mobile units disposed in a common housing having an IP-addressable I/O port. A monitoring and controlling computer system can be operated to run a test sequence of commands which are transmitted to the mobile units in order to generate

traffic according to various cellular radiocommunication system conditions which the system operator wishes to test. The test commands can be individually translated within the computer into mobile unit type-specific commands. Then, the computer can append an IP address to each mobile unit type-specific command, so that the command is received as a data packet(s)by the appropriate cluster and the command is forwarded within the cluster to the appropriate mobile unit.

The computer can forward the data packet(s) in a variety of ways. For example, the computer can include a short range, low power "Bluetooth" transceiver for sending the data packets over a radio link. Alternatively, an existing, wire-based local area network (LAN) employing an IP-compatible protocol, e.g., Ethernet, can be used as a transmission medium for the data packets.

Embodiments of the present invention provide a number of advantages and benefits when compared with the afore-described test systems. For example, by using a sequence of test commands that are translated into IP-addressed data packets, the present invention is able to employ existing data networks to convey information to mobile clusters rather than requiring that a myriad of dedicated, new wire lines be run to individual mobile stations. Moreover, by centralizing the processing of command and monitoring functions, as well as command translation functions at the computer rather than at individual mobile stations, the complexity and cost of the implementation are further reduced. Additionally, by providing IP addressable test clusters as described herein, there are no limitations regarding the distance between the monitoring and controlling computer system and the test mobiles and the test system, nor are there any limitations regarding the number of test mobiles which can be used.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 illustrates a conventional coaxial network testing system;

Fig. 2 is an exemplary embodiment of a fixed portion of the test system including an indoor antenna system; and

Fig. 3 illustrates a mobile cluster portion of a test system in accordance with exemplary embodiments of the present invention deployed in an exemplary indoor testing area.

DETAILED DESCRIPTION

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular circuits, circuit components, techniques, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well-known methods, devices, and circuits are omitted so as not to obscure the description of the present invention.

The exemplary testing systems discussed herein are described as having components which are intended to simulate an actual cellular radiocommunication system, i.e., systems having a fixed portion and a mobile portion. Purely for illustration, these exemplary embodiments portray the fixed portion of the test equipment as described in the above-incorporated patent application. However, those skilled in the art will appreciate that the IP-addressable mobile clusters and other concepts disclosed herein find use in test systems wherein the fixed portion of the system is represented using other types of test equipment.

Fig. 2 illustrates such a fixed portion of an exemplary test system. Depicted is a testing configuration comprising seven base stations, collectively referred to as reference numeral 200, that are connected to an array of twenty-one antennas collectively referred to as 205. It should be noted that the number of base stations and antennas is arbitrary and can be appropriately scaled up or down to formulate a particular set of test conditions. The antennas are positioned in a suitable pattern to create cells. The base stations 200 are represented as a transmitter (TX) and receiver

(RX) and are coupled to a duplexer 215. The duplexer 215 separates the transmitted signals to, and received signals from, the antenna array 205.

The array of antennas 205 are deployed in a pattern suitable for use within a confined laboratory space of test area. It should be noted that the distance between the antennas can be varied to suit particular design constraints. Furthermore, the distribution of antennas is administered in accordance with the cell plan selected to generate the desired testing conditions. The base stations 200 and antennas 205 are coupled with leads to an antenna matrix 220 which completes the connection of the individual base stations to the antennas. The leads that couple the base stations and antennas to the antenna matrix 220 are typically shielded coaxial cables to provide suitable signal transmission and isolation. The matrix 220 can be a standard off-the-shelf RF cross connect matrix which functions by cross connecting at least one antenna with an associated base station at any given time by way of a linked computer workstation (not shown).

Each antenna, when connected to a base station, creates an active cell for use in testing the air interface with a suitable mobile station or stations. The activated cells can be controlled by a computer workstation, for example, to synchronize the timing of the activated cells for simulating movement of a stationary mobile. This aspect of mobility is easily achieved by the manipulation of activated cells by programming the workstation via the antenna matrix 220 such that the appropriate base stations and the associated antennas are connected in a predefined pattern. The interested reader desiring more information regarding how mobility can be simulated using such an exemplary test set-up is referred to Figure 3 and the corresponding text in the above-incorporated by reference patent application.

According to exemplary embodiments of the present invention, the test mobile portion of the simulated cellular radiocommunication system can be implemented using IP-addressable clusters of mobile stations connected to a monitoring computer as illustrated in Figure 3. Therein, a plurality of mobile units, e.g., ten mobile units (referred to collectively in the Figure by reference numeral 300), are disposed in a housing 310. The mobile units 300 can be actual commercial units, or can be

"breadboard" implementations which are reduced to their necessary electrical and mechanical components. The mobile units 300 should be removably connectable to the housing 310, e.g., by employing well known car cradle devices within the housing 310. Each mobile unit will need access to an antenna, although it may or may not be necessary to provide each mobile unit with its own dedicated antenna as shown in Figure 3. To further utilize off-the-shelf components, the antennas can be implemented using well known "car kits" which connect mobile units within an automobile to an antenna disposed outside of the automobile to reduce the signal attenuation caused by the car's infrastructure. If desired, the antennas can be replaced by coaxial cables to permit other test equipment to be connected directly to the mobile units 300.

Each mobile unit can be powered by providing a connection to a power supply 320, e.g., a 12V DC power supply, which is also disposed within the housing 310. If cradles (not shown) are supplied to the housing to permit removable connections of the mobile units 300 thereto, then the power supply 320 can be connected to each cradle. If desired, the 12V DC power supply can be implemented as an AC/DC power converter which is connectable to an external AC power source.

Each mobile cluster also includes an IP server port 330 which interfaces the mobile units 300 with an IP network 340. The port 330 will have its own, unique IP address so that it handles only those data packets which are intended for mobile units 300 within this particular cluster. The IP server port 330 has an external I/O connection to receive/transmit data packets from and to the IP network 340, as well as individual ports for each of the mobile units 300, whereby the IP server port 330 can route individual packets received by the cluster to designated mobile units. Although the IP server port 330 can be implemented using any IP compatible port, one example of a suitable IP server port is an Etherlite port.

As mentioned above, each mobile cluster housing 310 (and therethrough each mobile unit 300) is connected to an IP network 340. This network 340 can be implemented in any number of ways, e.g., either using an existing, wire-based LAN or using a wireless data communication system. As an example of the former type of IP compatible network, IP network 340 can be implemented as an Ethernet local area

network. Alternatively, a wireless IP network 340 can be provided, e.g., a wireless local area network (WLAN) or one which is designed in accordance with the recently developed "Bluetooth" technology. Bluetooth is a universal radio interface in the 2.45 GHz frequency band that enables portable electronic devices to connect and communicate wirelessly via short-range, ad hoc networks. Readers interested in various details regarding the Bluetooth technology are referred to the article entitled "BLUETOOTH -- The universal radio interface for ad hoc, wireless connectivity" authored by Jaap Haartsen and found in the Ericsson Review, Telecommunications Technology Journal No. 3, 1998, the disclosure of which is incorporated here by reference.

Also connected to the IP network 340 is a monitoring/controlling computer 350. Computer 350 can be any type of computer, e.g., a UNIX workstation. Like the housings 310, computer 350 will also be equipped with an IP-compatible port (not shown), e.g., an Ethernet card, to communicate with the IP network 340. Computer 350 provides a test operator with the capability to run various types of tests which allow the operator to generate traffic in an actual cellular radiocommunication environment. The computer 350 can include one or more different types of memory devices, e.g., a hard drive, a non-volatile memory, a CD drive, a floppy drive, etc., on which a program controlling the mobiles can be stored. The program may be implemented as one or more script files or may be implemented in any other desired manner. Purely as an illustrative example, but without limitation with respect thereto, Applicants note that such scripts can be created to permit the operator to easily adjust and create script files, using a high-level, artificial script language which is easy for an operator to work with, e.g., using a tool known as the Mobile Subscriber Traffic Generator (MSTG) from ERISOFT. Alternatively, any other type of script language, programming language, etc. can be developed and/or implemented for this purpose. Each script file can contain a series of commands which control selected mobile units to operate in a predefined manner at predetermined moments to recreate a certain RF loading environment. For example, a script file could be stored that has a series of commands that instructs all of the mobile units in each cluster to attempt to access the fixed portion of the system

substantially simultaneously to test access capacity. The script file may include any input action normally executed by a human user at a mobile terminal. Those skilled in the art will appreciate that the number and type of script files which may be stored are too numerous to describe here.

Test systems including IP-addressable mobile clusters according to the present invention permit repeatable tests to be readily implemented, such as those involving a plurality of mobiles for testing interference on co-channels in cellular systems employing carrier frequency reuse plan in a plurality of cells. In these test scenarios, mobiles in different cells can be operated on co-channels in order to investigate interference related issues using an appropriate program or set of scripts. By way of example, the frequency reuse distance may be chosen by forming different cell patterns conforming to 3/9, 4/12 etc. cell plans. Other types of testing using the present invention include interference driven channel selection, inter-MSC handoffs, traffic overload control, directed retry due to voice channel congestion, and base station power control issues, for example.

The present invention contemplates a space-efficient test platform that provides a more realistic environment for testing the air interface. Since real mobile stations are preferably used in the test process, handoff and interference problems from the field can be readily investigated in the laboratory. Furthermore, the intrinsic nature of the testing using stationary components provides for consistent environmental conditions that is particularly suitable for repeat testing. Hence repetition of identical tests enables fine tuning of the system by optimizing parameters and permits the evaluation of new functions and algorithms under the same conditions.

The script files may be created, edited, stored and invoked using a graphical user interface (GUI) implemented using the display of the computer 350. Since the mobile units 300 are not designed, however, to read and implement the commands as they are set forth in the high-level script language, exemplary embodiments of the present invention provide for translation of the invoked script file into more primitive, machine-level instructions. As will be appreciated by those skilled in the art, the particular type of instructions into which the script file is translated will vary from

mobile station to mobile station based on the manufacturer, model, etc. The translation can be provided by a software program resident in computer 350, e.g., a so-called driver, with a different driver being provided for each different type of mobile unit that is removably connected to a cluster. If different types of mobile units are being used in a test at the same time, e.g., different clusters 310 have different mobile unit types, possibly even within the same cluster, then the computer may have plural drivers concurrently running to selectively perform translation into the appropriate lower level primitives.

After translation into a mobile unit-type command primitive, computer 350 needs to transmit the translated commands to the appropriate cluster housing 310. According to exemplary embodiments of the present invention, this can be accomplished by appending an IP address, that is uniquely assigned to the appropriate cluster housing, to the translated command. Thus, the computer 350 creates a data packet which includes the IP address of the cluster housing 310, the translated command and, optionally, an individual mobile unit identifier. In this way, the respective IP server port 330 will acquire each data packet that is associated with its unique IP address, segment the packet to acquire the mobile unit identifier and provide the command directly to the appropriate mobile unit. According to exemplary embodiments of the present invention, the data packetization can be performed using the well known asynchronous transfer mode (ATM) protocols, however, those skilled in the art will recognize that various types of data packet bearer protocols could be used as an alternative.

While the invention has been described with reference to specific exemplary embodiments, the description is illustrative of the inventive concept and is not to be construed as limiting to the invention. In particular, the inventive concept is also applicable to systems operating in accordance with Code Division Multiple Access (CDMA), for example. Various modifications and steps may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

<u>WHAT IS CLAIMED IS</u>:

1. A system for testing cellular radiocommunication equipment, said equipment including a fixed portion and a mobile portion, said system comprising:

at least one transceiver operating as said fixed portion of a cellular radiocommunication system for transmitting and receiving signals over an air interface;

at least one cluster of mobile units disposed in a housing, said mobile units being controllable to transmit and receive signals over said air interface to said at least one transceiver; and

a computer for controlling and monitoring operation of said at least one cluster of mobile units,

wherein said computer is connected to said at least one cluster of mobile units using an Internet Protocol (IP) compatible medium,

wherein said at least one cluster of mobile units is assigned an IP address, such that said computer can address a command to a selected cluster.

2. The test system of claim 1, wherein each mobile unit within said at least one cluster is individually controllable by said computer.

3. The test system of claim 1, wherein said IP compatible medium includes a local area network.

4. The test system of claim 1, wherein said IP compatible medium includes a radio link.

5. The test system of claim 1, wherein said IP compatible medium includes a public switched telephone network (PSTN).

6. The test system of claim 1, wherein said computer includes a memory device having stored therein a program which is repeatably usable to send different

predetermined commands at predetermined times to said at least one cluster of mobile units using said IP address.

7. The test system of claim 6, wherein said computer transmits each of said commands on said IP compatible medium as at least one data packet, said at least one data packet including:

(a) said IP address of said at least one cluster of mobile units;

(b) an identifier of at least one of said mobile units within said cluster that is the intended recipient of said command; and

(c) said command.

8. The test system of claim 6, wherein said computer further comprises:

a driver for translating each command in said program into a mobile unit type-specific command prior to transmission thereof.

9. The test system of claim 6, wherein said program includes at least one script file.

10. The test system of claim 7, wherein said at least one data packet is sent using an asynchronous transfer mode (ATM) protocol.

11. A radiocommunication test unit comprising:

a housing;

a plurality of mobile units disposed within said housing; and

an IP compatible interface, having a respective connection to each of said plurality of mobile units and an I/O port for permitting data communication between said test unit and an external IP compatible network.

12. The test unit of claim 11, wherein said I/O port includes a radio transceiver and said external IP compatible network is a radiocommunication system.

13. The test unit of claim 11, wherein said I/O port includes an Ethernet device and said external IP compatible network is a local area network.

14. The test unit of claim 11, further comprising:

a plurality of cradles, each associated with one of said plurality of mobile units, wherein said mobile units are removably connected to said housing.

15. A method for testing a radiocommunication system comprising the steps of:

reading, from a memory device in a computer, a first command for controlling operation of a mobile unit;

translating, in said computer, said first command into a second command based on a type of said mobile unit;

appending, in said computer, an IP address associated with said mobile unit to said second command; and

transmitting, from said computer, said IP address and said second command as a data packet to said mobile unit.

16. The method of claim 15, wherein said step of transmitting further comprises the step of:

transmitting said data packet using an asynchronous transfer mode (ATM) protocol.

17. The method of claim 15, wherein said step of transmitting further comprises the step of:

transmitting said data packet using a radiocommunication network.

18. The method of claim 15, wherein said step of transmitting further comprises the step of:

transmitting said data packet using a local area network.

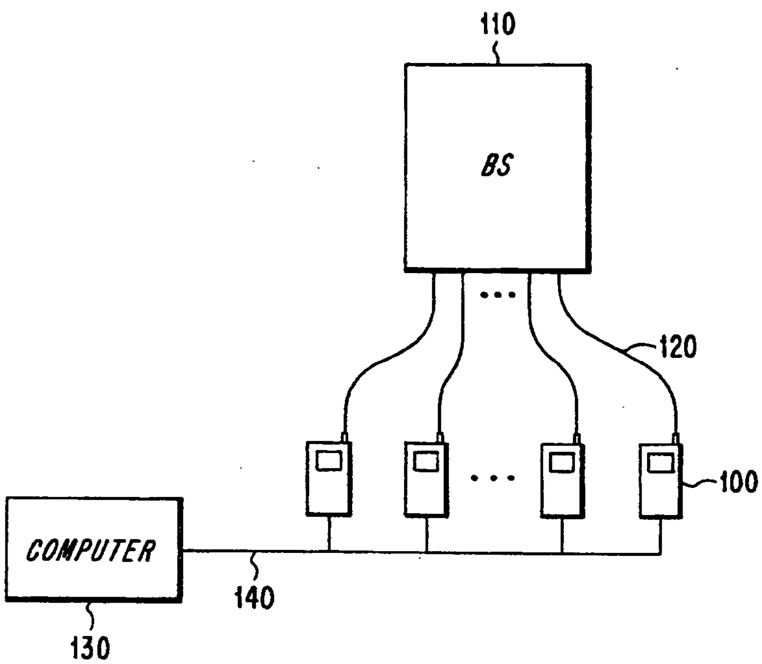
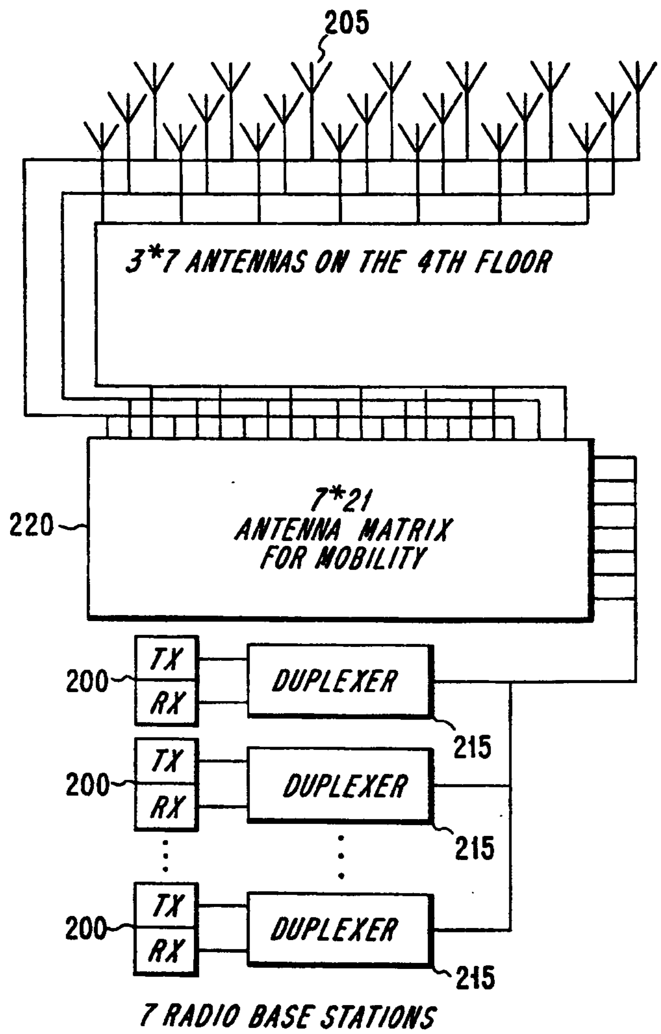


Fig. 1
(PRIOR ART)


205
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FOR MOBILITY
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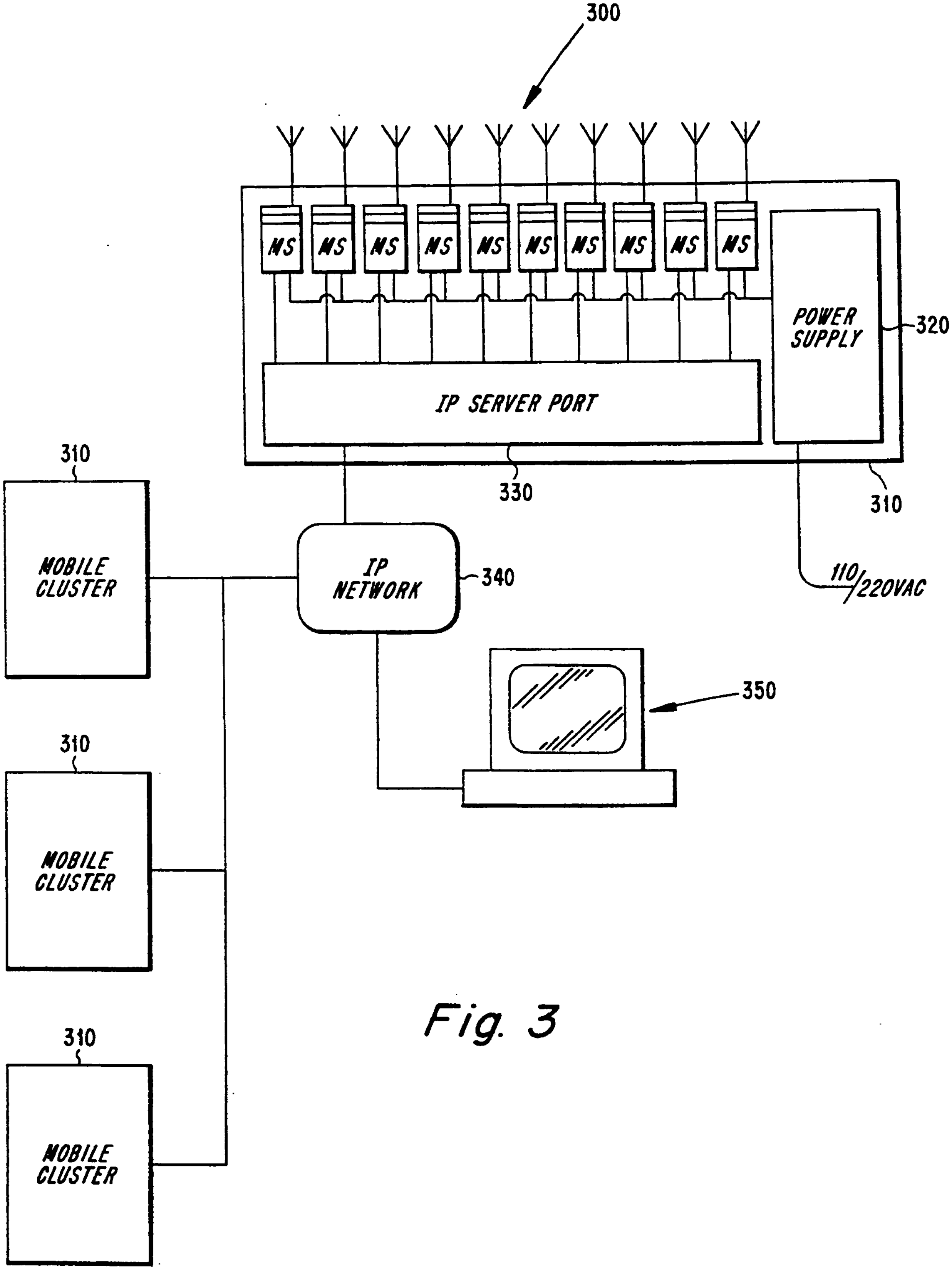
7 RADIO BASE STATIONS

Fig. 2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IP NETWORK
340
110/220VAC
350
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MOBILE CLUSTER
310
MOBILE CLUSTER

Fig. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/02285

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/34 H04B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 26616 A (TELEFONAKTIEBOLAGET LM ERICSSON) 18 June 1998 (1998-06-18)	1-3,5,6, 8,11
Y	abstract	4,7,12, 13,15, 17,18
A	page 114, right-hand column, line 30 -page 115, left-hand column, line 13 page 5, line 1 - line 14 page 7, line 9 -page 8, line 2; claims 1-5 --- -/--	8-10,14, 16

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 May 2000	07/06/2000

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/SE 99/02285

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